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**Assessment of Conservation Priorities for Gross National Happiness**

# Foreword



It is very worrying to wake up to the news of environmental degradation, climate change, and animal extinctions around the world, almost every day. Then again, there is some consolation in the fact that we are in Bhutan, the nation that strove to safeguard its remarkable biodiversity and stood up to minimizing climate change in its humble ways. And as a country that has its culture and practices entwined with Buddhist principles, it has endeavored to transform its wilderness into homes for all animals and species.

Blessed by the profound visionary monarchs and their leaderships, Bhutan has never faltered in environment conservation efforts and remains the only carbon-negative country in the world. However, it is referred to as one of the 36 global hotspots of biological diversity, in other words, a nation within an Eastern Himalayan region that contains an enormous amount of biodiversity at risk.

Any consolations for Bhutan are short-lived, as reality dawns that this planet is a precious home for every being, not just limited to humans. Greenhouse gas emissions obviously transcend political boundaries, challenging the conservation policies and sincere efforts of any particular nation.

We are also learning of the mass extinction of species globally, occurring at an unprecedented rate. Scientific consortia within the United Nations are predicting that over one million species could be exterminated by the end of this century, if not sooner.

What's worse? These are all human induced, posing the greatest threats of all times to the present and future generations of most documented organisms, from pollinators to large mammals.

As a medical practitioner who insists on timely action on the part of the patient to prevent persistent illnesses, I can totally echo the sentiments and concerns of scientists in different institutes around the world, calling upon governments to come to the rescue of such biocultural heritage.

It is also painful to learn that efforts to respond to such taxonomic complexity, be it for conservation biologists or governments, are further hampered by the persistent absence of information.

The story is the same for Bhutan. As the authors of this study reveal, we know very little about most species like the rare fungi, freshwater fish, butterflies, and parasites that are crucial to the well-being of healthy ecosystems.

As Bhutan cautiously follows the principles of Gross National Happiness (GNH) and treads toward sustainable development goals, conservation of environment is one of the main building blocks. It is imperative that a clear scientific understanding is required to “diagnose” the ecological health and “prescribe” preventive remedies and solutions to the challenges.

This is why I welcome the efforts of Dr. Tshewang, Ms. Morrison, and Dr. Tobias – and the many Bhutanese scientific colleagues and technical experts who have generously assisted them – in coming out with a publication of such importance and relevance.

The publication is ecologically provocative and revealing for the government. Through an extensive review of the scientific and anthropological literature, seizing upon so-called gap analyses, they have set forth timely recommendations for conservation policies, strategies, and actions.

The book provides technical and deeply considered assessments of the state of Bhutan’s environment, its multiple, human-induced stressors and pressures, as well as extremely sound, practical techniques that would address conservation strategies in the Himalayas and, by implication, worldwide.

In any given ecosystem, every single species of animal or plant is a vital member of such communities. It is an important component in the “fabric” of life. Therefore, safeguarding the natural environment is everybody’s responsibility – at all levels of society.

This book is one classic example of the contribution to conservation biology by a private consultancy firm and a nongovernmental organization. I offer my heartfelt appreciation.



HE Lyonchen (Dr.) Lotay Tshering  
Prime Minister  
Royal Government of Bhutan

# Preface



Fostered and guided by the visionary policies of the enlightened monarchs and Buddhist perspectives, Bhutan emerged into the twenty-first century as one of the world’s most conservation-driven, habitat-protected nations in the world. Yet, Bhutan is witnessing unprecedented climate change, with a mean temperature increase of 1.3 °C over the last two decades, as reported by the authors of this book. In fact, the whole world is witnessing record-breaking weather patterns every year – and such trajectories of global warming trends do not bode well for a sustainable future, unless we change its course while implementing mitigation, adaptation, and resiliency protocols. Moreover, Bhutan now finds itself right in the center of one of the world’s 36 terrestrial global hotspots of biological diversity, the “Himalayan” hotspot, abutting up against the Indo-Burma hotspot. According to the Critical Ecosystem Partnership Fund, these high-biodiversity hotspots are defined as areas (a mere 2.4% of the Earth’s terrestrial surface area) that “Contain at least 1,500 species of vascular plants found nowhere else on Earth (known as “endemic” species)... [and an area that has] lost at least 70 percent of its primary native vegetation.” It is in that light that an overall assessment of conservation priorities for Bhutan has become essential in view of many confronting challenges posed by global warming and human activities.

As the Royal Government of Bhutan aligns policies, plans, and programs with responsive measures to resolve the daunting challenges of our times in this time known by scientists as the Anthropocene, I am glad to note the Bhutanese private sector and a major US-based nongovernmental organization coming together to



participate in this process. Just 1 year ago, the authors Dr. Tshewang, Ms. Morrison, and Dr. Tobias consulted me on their proposal to assess the conservation priorities for Bhutan. Now, this year, I am glad to introduce their book that embraces a holistic approach to conservation biology including Bhutan's state of environment and the various drivers and pressures affecting it. The book encompasses nonviolent approaches to human-wildlife conflict; Buddhist perspectives in animal protection, animal rights, and animal liberation; and recommended conservation strategies for endemic, threatened, and underrepresented species, including valuable material on the ecological significance of new conservation technologies and the overall and economic benefits to a variety of stakeholders of conservation in Bhutan.

Thus far, Bhutan's conservation success has been largely attributed to the prudent policies and management of the country's extensive protected area network and biological corridors, with tremendous importance and focus having been placed upon many charismatic and umbrella species. In their analysis of so-called taxonomic bias, Dr. Tshewang, Ms. Morrison, and Dr. Tobias (who previously joined forces in their 2018 book, *Bionomics in the Dragon Kingdom: Ecology, Economics and Ethics in Bhutan*) examine the conservation status of all known and/or statistically projected life forms within Bhutan and thereby emphasize the subtle but crucial underpinnings and ecological significance of new conservation strategies yet to be implemented across whole realms of critically endangered, endangered, endemic, and underrepresented species in the country.

With striking contemporary relevance, the authors' assessments include such heretofore understudied potential ecological benefits of some of the most underrepresented or lesser-known species (all exposed to the threats of climate change and human activities), including microbes, spiders, bats, and bryophytes, each with profound importance to Bhutanese nature, as well as the potential for economic and human health applications, as in the case of ethically applied (non-inflictive) biomedical research.

For Bhutan, food security is one of the most serious threats immediately posed by the Anthropocene – the massive extinction spasm sweeping the planet, a veritable “epoch” (as geologists, hydrologists, and other scientists think of it), a period of immense environmental flux and destruction that is in sync with the debilitating effects of climate change and systemic climate anomalies. The authors recommend preservation of the genetic resources found in Bhutan, including isolated maintenance in a high-security context of the richly diverse crop seeds and sprouts and microbial culture, all under temperature conditions equivalent to those found in permafrost soils within the Himalayan glaciers, for ensuring food security in perpetuity. Bhutan's wealth represented in the diversity of its crop genetic resources and soil microflora could be one possible solution to food instability in the face of unpredictable climate change impacts on agricultural farming in the region. This is particularly crucial to consider given that the majority of Bhutan's population is rural and dependent upon the most mountainous topography of any nation in the world, with less than 3% of it being arable.

In the conservation world, human-wildlife conflict is a global challenge because of competition over resources and encroachment into habitats by such species as

wild boar and elephants. It still remains one of the major concerns of Bhutan's conservation and farming sectors. This essential book provides numerous innovative and pragmatic techniques including immunocontraceptive techniques for nonviolent dog population control – the resolution of such conflict providing animal rights and species protection measures within ancient Buddhist perspectives of coexistence. Drawing from the Gross National Happiness philosophy, the authors propose an animal welfare standard, stipulated by world animal health organizations, that could be elegantly integrated within Bhutan's unique biocultural heritage and measured in a paradigm of the existing Gross National Happiness index – in other words, the first Gross National Happiness Index for Animals and Plants ever advocated in any country. So noble a concept warrants extensive research for the development of indices and practical applications that could further ensure the widespread promulgation of a Buddhist, nonviolent approach to nature at every level of human life throughout Bhutan. But such enactment will also entail a serious commitment from every juncture of governance, jurisprudence, and the virtuous work of communities, NGOs, and individuals.

This book has the very real potential to be of high relevance and informative depth for policy makers, planners, researchers, professors, students, and conservationists. I want to extend my sincere congratulations to Dr. Tshewang, Ms. Morrison, and Dr. Tobias and the Technical Expert Working Group representing various agencies and the other individuals who contributed to the accomplishment of this wonderful and vital book.



HE Lyonpo Yeshey Penjore  
Minister for Agriculture and Forests  
Royal Government of Bhutan

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# Executive Summary

Located in the heart of the Eastern Himalayas, Bhutan practices the philosophy of Gross National Happiness (“GNH”) that embraces environment conservation as one of the main building blocks for its sustainable development goals. Bhutan’s conservation strategy and success is largely driven by the strong political will and visionary leadership of His Majesty the King of Bhutan. In addition, Bhutan’s Buddhist perspectives on the respect for nature, and its strategic enforcement of a wide-ranging stringent set of internal regulations and controls has also helped the country – as an active member of the international community – to better fulfill the implementation of various multilateral environmental agreements. While it emerged into the twenty-first century as one of the 36 global terrestrial “hotspots” in biological diversity conservation ranks, Bhutan’s sheer commitment, with more than 51% of its territory being managed under the explicit status of a protected area network and more than 70% of the land under forest cover, is perhaps an “unconditional reality” of its exemplary dedication to protect the planet despite its smallness in size and economy. In the face of imminent severe threats of global warming, Bhutan represents the fact to the world that “a small country with a big conservation commitment” can make an enormous contribution to the global community. The Constitution of Bhutan mandates a minimum of 60% forest cover, while Bhutan has also made a “bold” international commitment to remain carbon neutral at the UNFCCC Conference at Copenhagen in 2009. At the regional level, Bhutan protects the Water Towers of Asia (that glacial expanse of the Himalayas) which are a critical resource bulwark for one-fifth of the global population downstream in South Asia. Such protections invariably help mitigate climate change by acting as a nationwide carbon sink through its carbon-neutral policies. In short, Bhutan has long represented one of the world’s foremost protectors of biodiversity conservation, ecological good governance, and societal sustainability at a period when the world has entered the Anthropocene – an epoch of mass extinctions. Time is running out for the world’s 233 nations to act wisely and quickly in accordance with the unprecedented demands of a true global crisis. And any degree of complacency or lack of continued fine-tuning can lead to setbacks, even failure in future progress, and could even reverse some of Bhutan’s conservation achievements made thus far.

Thus, in keeping with the overarching policy of GNH and the Bhutan 2020: A Vision for Peace, Prosperity and Happiness initiative, the ACPB (Assessment of Conservation Priorities for Bhutan) project provides an urgently needed overview of holistic and multiple assessments and recommendations on the “state of the environment” commitments and legal mandates and the nation’s Buddhist perspectives on protection of nature inclusive of animal rights and adoption of nonviolent deployable techniques for resolution of human-wildlife conflict. In fact, ACPB represents a major attempt to assess threatened and endangered species, recognizing near-term risks of extinction, and – quite importantly – the underrepresented or lesser-known species and the Bhutanese conservation strategies required to keep such species (previously under the scientific radar) from rising to the status of endangered, the kind of research and policy recommendations that rarely surface in an era swept over by so many other imperatives and wildfires.

The ACPB project productively engaged various communities across Bhutan and a stellar Technical Expert Working Group (including 12 key collaborators) representing the various government agencies, nongovernmental agencies, monastic bodies, individual scientists, and farmers for consultations and viewpoints for their critical input into the project. In addition, at least 60 Key Informant Interviews with the representatives of these agencies have taken place. A multidisciplinary analysis of the various drivers and pressures on Bhutan’s natural environment and biological diversity including the animals and crops has been deployed to developing protection and conservation strategies and policy responses. While the population increase does not seem to be significant, the anthropogenic activities and the pressure including extraction of natural resources such as timber and fuelwood, growing urban areas, pollution and fossil fuels, waste generation, land use changes, hydropower development, bio-invasive species, etc. are found to be on the increase across the country. Even as a carbon-negative country, our assessments explicitly indicate that the serious threats of climate change are looming large across the country with a temperature rise of 1.3 °C over the last two decades, which is nearing the threshold level of 2 °C rise above the preindustrial levels. Such unprecedented rise in temperature would pose uniquely perilous challenges in keeping up with its conservation commitments because of its relatively low adaptive capacity and being one of the least “developed” countries in the world. Over the recent years, associated with this temperature rise, Bhutan has been experiencing the impacts of climate change disasters like glacial lake outburst floods (the climate change “GLOF” effect), flash floods, landslides, wind storms, forest fires, etc., and such adverse events have been impacting this country mainly because of the pollution caused by the industrialized nations. Thus, Bhutan is at a crossroads between its conservation commitments and legacies and the myriad thrusts of economic development activities. While many national adaptation and mitigation measures are implemented through various programs and institutional mechanisms, there is a need for climate change policy or a climate white paper that provides a prudent and holistic approach toward making a concerted effort in tackling climate change impacts in the country.

In the conservation worlds of animal welfare, animal protection, animal rights, and animal liberation, the strong Buddhist belief of compassion toward all sentient

beings practiced through liberation of lives (*Tshethar*) from slaughter and the complete ban on the sale of meat during religious holidays all can most certainly be replicated through similar legal briefs and consequent protection of animals in other parts of the world. In that respect, Bhutanese biocultural values, the ecological sciences, and their summary in ACPB support global awareness and advocacy along the lines of Gross National Happiness that has been adopted by the General Assembly of the United Nations in its resolution 66/281 of July 12, 2012, proclaiming the 20th of March as the International “Day of Happiness” recognizing the very relevance of “happiness” which this project also proposes. A Gross National Happiness Index for Animals as a recommendation to be submitted for the celebration of animal rights and protection considerations is one of the cornerstones of the ACPB report: a long-overdue, science- and ethics-based template for merging conservation biology, animal rights, and local, state, and transboundary conservation policies. Some 182 member countries of the World Organisation for Animal Health (“WOAH”) prescribe an animal welfare index which is far from the ultimate realization of real happiness in animals. And it is precisely for such organizations that this radically new ACPB “GNH Index For Animals” concept may well exert important traction, however incrementally. With due considerations of scientific animal welfare standards prescribed by WOAH, integration of the Buddhist values of compassion and nonviolence toward animals (including the ban of slaughter on religious holidays) with such scientific standards could have a much-needed meaningful provision for an effective animal welfare policy in Bhutan and beyond.

As in many other countries, human-wildlife conflict is increasingly becoming a serious concern to Bhutan’s agriculture and livestock farming and the conservation efforts. Deeply committed to animal rights and conservation biology, this project recommends a set of best and safe nonviolent approaches to human-wildlife conflict through an extensive global literature review, as well as the analysis of practical experiences of many on the ground in Bhutan who have been interviewed. Empirical evidence indicates that retaliatory actions using lethal weapons on some of the predators create societal interferences aggravating the human-wildlife conflict as discussed in the book. Thus, recommendations are proposed on safety approaches and strategies, as well as an innovative approach using immunocontraceptive vaccines (antifertility vaccine) for the population control of street dogs and wild animals that would go a long way in the resolution of the conflict for a peaceful coexistence between the humans and wildlife. Besides, the book recommends a human-wildlife conflict policy of Bhutan that encompasses preventive and mitigation measures required for the resolution of the conflict.

Because of global warming and so many cumulative pressures on the environment (described at great length in the ACPB book), an in-depth analysis of the conservation status at the species levels of the Animalia and Plantae kingdoms in Bhutan has revealed, among many other things, at least 70 vulnerable species, 43 endangered species, 21 critically endangered species, and 2 plant species that have tragically gone extinct (including 1 species that has gone extinct in the wild). While these accounts in Bhutan may seem insignificant in comparison with the global extinction of some 946 species in Animalia and Plantae kingdoms, thus far, it should

be a point of grave concern for the country, as the trend could continue as global warming escalates.

Simultaneously, the taxonomic bias of underrepresented species in Bhutan has been analyzed with the kingdoms Plantae, Animalia, Fungi, Chromista, Eubacteria, Protista, and Archaeobacteria in Bhutan currently revealing 5,369, 5,114, 690, 55, 18, 2, and 0 recorded species, respectively. Apart from the severe underrepresentation of the species and the taxonomic bias in the kingdoms of Chromista, Eubacteria, Protista, and Archaeobacteria, the taxonomic data falls far short of accounting for the likely full range of Bhutanese diversity even in the kingdoms of Plantae, Animalia, and Fungi. Current international tabulations on species diversity - with the increasing scientific convergence of consensus - suggests that the true quanta of taxa and sub-taxa are greater than previously thought by possibly two magnitudes of ten, if all seven kingdoms of life forms are extrapolated (far beyond the assessment infrastructural capacity of the IUCN or any other global research bodies, let alone any one nation). But the ethics and pragmatic mechanisms for safeguarding this fragile and prolific biosphere require courageous new insights and grounded leaps of the collective human imagination. As a matter of fact, the vast data gaps and underrepresentations of taxa under the kingdoms of Chromista, Eubacteria, Protista, and Archaeobacteria are the very biological preconditions for the viability of all invertebrates and vertebrates. Apart from the mega species that are iconic and keystone species in food webs of the ecosystems, it is precisely these microscopic worlds within worlds that are key to such areas as agriculture. For example, the symbiotic fungi that form mycorrhizal relationships with botanical hosts, dependent upon the vast array of native bacterial agents, are critical to most plant life on Earth. Recognizing a nation's biodiversity is the the first important step toward obtaining all necessary legal protections for those taxa, and, hence, ACPB provides a series of information on ecological significance, GIS maps, and habitats that can help accelerate the consolidation of data and disseminate its results in the most effective manner in order to help species and habitats at risk.

Why then is all of this so important at this time? For generations, scientists have been studying virtually every known organism on the planet. But only in this generation do they – and the general public and policy leaders – recognize that there is, in fact, a biological ticking clock pertaining to climate change and the Anthropocene: an epoch that is tantamount to the sixth extinction spasm in the annals of biology in the 4.2 billion years of organic evolution on Earth. We are all interdependent. Our health depends upon the health depends upon the wellbeing of every single organism, most of which (particularly microbiota) have been ignored or taken for granted or are subject to only the most specialized scientific and medical scrutiny. In fact, biomedical advances now represent the largest area of critical new research in the health sciences. Yet, only a small cadre of geneticists and molecular biologists working on new genomic advances and pharmaceutical breakthroughs pertaining to human health have shown intense interest, with public/private sector financing, in the value of these microscopic creatures. Indeed, bacteria, algae, phytoplankton, etc. – these are the real engines of life, of evolution, of our survival and the survival of the entire biosphere. We ignore them at our peril. ACPB endeavors to diagnose

such issues and intellectual disparities, by presenting preliminary data and scientific literature review – to the extent that it exists – on Bhutanese species in the global context.

In view of the tremendous ecological significances and multiple socioeconomic benefits including food security, biomedical research, clean water, and environment, ACPB proposes concrete and exhaustive recommendations for conservation strategies of the critically endangered species, endangered species, and underrepresented species, inclusively, to halt the extinction crisis on this one planet we all share. In a shared landscape at the foothills of the Eastern Himalayas, endowed with tremendous biological diversity and natural resources, transboundary conservation programs at the international border areas could be effective and promising to halt the decline of the threatened species and ecosystems and begin with restoration effort. As a major policy intervention for the protection of critically endangered, endangered, and vulnerable species, the “Endangered Wildlife Act” of Bhutan could provide a strong legal protection as some of these species may not be receiving legal protection under the current national legislations.

As the most underrepresented species in the kingdoms comprise microbes, and given their tremendous potential for biotechnological applications, a repository of microbial culture as a gene bank is being proposed due to the possible threat of climate change and commercial agriculture using pesticides. Because of the modernization of agriculture and monoculture of crop seeds, coupled with climate change impacts, the preservation of crop genetic resources as “Black Box” in secured locations of Himalayan glaciers under permafrost conditions would be the greatest source of hope for food security and posterity in this epoch of Anthropocene and in light of frequent attacks by natural calamities.

On the whole, the ACPB project in the environmental sector is considered very timely as the Bhutan 2020 document with the vision of peace, prosperity, and happiness needs to be updated by year 2021.



# Biodiversity Terms

Vascular plants	Plants possessing well-developed conducting tissue for the transport of water, mineral salts, and sugar. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a>
Ferns	Asexual plants that bear minute spores on the back of the fronds or leaves. They usually grow in humid soil, sometimes epiphytically on trees, and in tropical climates. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a>
Liverworts and hornworts	Liverworts and hornworts are flowerless plants that produce spores in capsules. <a href="https://www.anbg.gov.au/bryophyte/">https://www.anbg.gov.au/bryophyte/</a>
Mosses	Mosses are flowerless plants with fruits containing spores. The diverse species of mosses grow in various places including on rocks and tree trunks and in running water. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a> & <a href="https://www.anbg.gov.au/bryophyte/">https://www.anbg.gov.au/bryophyte/</a>
Algae	The algae group consists of Rhodophyta (red algae), Chlorophyta (green algae), Phaeophyta (brown algae), and Chrysophyta (diatoms). They propagate spores; are unicellular or not differentiated into root, stem, and leaf; and generally contain chlorophyll. This group includes seaweed in addition to numerous freshwater plants. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a>
Green algae	Green algae is the most diverse group of algae. It contains photosynthetic pigments similar to those found in higher plants. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a> & <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>

Brown algae	The largest of the chromists, with the largest brown algae reaching over 30 meters in length. This algal group includes large seaweed genera such as <i>Laminaria</i> (kelp) and <i>Fucus</i> . <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a> & <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Eubacteria	Eubacteria is one of two subdivisions of the prokaryotes (the other being <i>Archaeobacteria</i> ). The diverse range of organisms in this group live in varying environments and fulfil a multitude of roles: they may be disease causing, anaerobic, autotrophs, or vitall for nutrient cycling in ecosystems. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a> & <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Cyanobacteria	Also known as blue-green algae, they are aquatic, photosynthetic bacteria that are usually unicellular and grow in visible colonies. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Chromista	Chromista is a kingdom-level taxon that consists of mostly photosynthetic organisms, some of which (such as kelp) play vital roles in aquatic ecosystems. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Diatoms	Diatoms are unicellular, photosynthetic, aquatic microorganisms found in abundance in both marine and freshwater ecosystems. They are an important food source for marine organisms. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Protista	A kingdom consisting of eukaryotes that do not fall into the other three kingdoms: animals, plants, and fungi. This taxon is extremely diverse and includes amoebae, algae, and slime molds. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Plasmodium	Plasmodium are slime molds that are extremely large single cells with thousands of nuclei. Slime molds live in moist, terrestrial habitats, such as on decaying wood or fresh cow dung. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a> ,
Mammals	Representing the highest class of Vertebrata, mammals have hair, and are warm-blooded, and mammalian young are initially fed milk (or an analogous fluid) secreted by the mammary glands of the mother. <a href="http://www.mondofacto.com/dictionary/contents/biology.html">http://www.mondofacto.com/dictionary/contents/biology.html</a>

Diptera	An order of insects, the “true flies,” which have one pair of functional wings and a pair of hind wings that have evolved into balancing organs called halteres. Their mouthparts have been modified for sucking or piercing, and this group includes flies and mosquitoes. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a> & <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Hemiptera	Also known as “true bugs,” they all have piercing mouthparts contained in a beak (or rostrum), which they use to suck fluids (usually) from plants. This order includes aphids, cicadas, and scale insects. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a> & <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Isoptera	An infraorder under the order Blattodea consisting of termites – insects that live in social groups and have strong biting mouthparts to chew through seeds, wood, or leaves. <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a> . The Order Insect, and forming part of the Blattodea.
Orthoptera	An order of insects including grasshoppers and crickets that often possess large hind legs used for jumping. Many species have the ability to “sing” by rubbing their legs together or against the side of their bodies. <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Plecoptera	This order includes stoneflies, a small group of aquatic insects which as adults resemble lacewings, but are more closely related to mayflies. <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Hymenoptera	A large order of insects including bees, ants, wasps, and sawflies. Some species are very social, and this group also includes important pollinators of flowering plants. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a> & <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Coleoptera	The largest order of insects globally, comprising beetles and weevils. <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Lepidoptera	An order of insects that include butterflies and moths. They undergo complete metamorphosis, from ova (egg), from which emerge larvae (caterpillars), to quiescent pupae, from which emerge the winged adults. <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>
Arthropoda	A phylum of invertebrates with a joined exoskeleton. This group includes arachnids, crustaceans, and insects. <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a>

Odonata	This order, comprising some of the most ancient and largest flying invertebrates ever to have inhabited the planet, includes dragonflies and damselflies. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a> & <a href="https://www.amentsoc.org/">https://www.amentsoc.org/</a> ,
Nematoda	Nematodes or roundworms can be found almost anywhere on Earth, including soils and sediments, plants, animals, ice, and hot springs. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Mollusca	One of the most diverse divisions of the animal kingdom with soft bodies that are generally covered by a hard exoskeleton. It includes organisms such as snails, octopuses, squid, clams, and oysters. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Fungi	Fungi feed by absorbing nutrients from their surrounding environment, reproduce through spores, and play a vital role in their symbiotic relationship with plants, assisting plants to acquire water and nutrients from the soil. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>
Herpetofauna	A term used to classify amphibians and reptiles together. Herpetofauna are ectotherms and most lay eggs, although some give birth to live young. <a href="https://ucmp.berkeley.edu/">https://ucmp.berkeley.edu/</a>

## Definition of Land Cover Classification

Forest	Forest means land with trees spanning more than 0.5 hectare and higher than 5 meters and a canopy cover of more than 10%. It does not include land that is predominantly under agricultural or urban land use (National Forest Policy of Bhutan, 2011).
Blue pine forest	Consists of pure or dominant stands of blue pine, usually at an altitude between 1500 masl and 3200 masl. Smaller areas of mixed conifers and broadleaf forests may occur interspersed in the blue pine mapping unit, but because of their small areas, they are often left unrecorded.
Chir pine forest	Consists normally of pure stands of chir pine, usually at altitudes between 700 masl and 2000 masl at relatively dry areas. However, in depressions and water courses, broadleaf forests might occur, but these areas are usually small and included within the chir pine mapping unit.
Mixed conifer forest	Includes mixed stands of spruce, hemlock, juniper, fir, larch, taxus, and blue pine. Some broadleaf inclusions are also common particularly oaks, rhododendron, maple, and birch. It usually occurs between 2500 masl and 3500 masl.
Fir forest	Consists either of largely pure stands of fir or few stands of other species such as junipers, taxus, and larch. This category occurs mostly above 3000 masl.
Alpine scrub	Woody plant characterized by stunted growth (height less than 5 meters) due to harsh conditions. They are found at higher elevation above 3500 masl close to tree line. Predominant species include dwarf rhododendrons and junipers.

Shrubs	Perennial plants with a persistent and woody stem without any defined main stem with height less than 5 meters. It also includes abandoned agricultural fields with overgrown bushes and other regenerations in disturbed areas.
Meadows	Include any areas dominated by grasses or any herbaceous plant without or with few scattered trees or shrubs on them. It occurs at all elevations, but is relatively more common at higher elevations.
Cultivated agricultural land	Includes only those agricultural lands that are cultivated at the time of land cover assessment. It is further divided into subclasses.
<i>Chhuzhing</i>	Irrigated and/or bench-terraced agricultural land for paddy-based cropping systems.
<i>Kamzhing</i>	Cultivated rain-fed areas (dry land). Some Kamzhing lands have a certain level of land shaping.
Orchards	Refer to planted fruit-bearing trees like apple, orange, areca nut, etc.
Built-up areas	Include artificial constructions covering the land with an impervious (e.g., concrete, CGI sheet, thatch) surface. It includes airports, rural settlements, urban areas, schools and institutes, industrial areas, hospital premises, sewage treatment plants, sports and leisure facilities, and roads.
Non-built-up areas	Absence of the original (semi-) natural cover mainly due to anthropogenic factors. It includes waste dump sites, mines, stone quarries, and other extraction sites.
Water bodies	Natural and artificially created water bodies. It is further divided into two subclasses.
Lakes	Areas of perennial and natural water surrounded by land. It includes both natural and manmade.
Rivers	Perennial flow of water and the riverbeds. It also includes artificially constructed reservoir (dam) along the course of perennial rivers.
Snow and glaciers	Includes both perpetual and seasonal snow cover and glaciers.
Moraines	Mass of rocks and sediments carried down and deposited by a glacier typically as ridges at its edges or extremity.
Scree	Mass of small loose stones that form or cover a slope on a mountain.
Landslide	Includes mass movement of soil debris due to gravitational force triggered by other factors such as rainfall and earthquakes.
Rocky outcrops	Rocky outcrops refer to natural cliffs and rocky areas.

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